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SPACE INVESTIGATION IN THE USSR--PAST, PRESENT, AND FUTURE

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PREFACE

This paper was prepared for presentation at the 1959 National Telemetering Conference, the theme of which is "The Investigation of Space." The Conference, sponsored annually by the American Rocket Society, the Instrument Society of America, the Institute of Aeronautical Sciences, and the American Institute of Electrical Engineers, will take place May 25-27, 1959, at the Brown Palace and the Cosmopolitan Hotel in Denver, Colorado.

SPACE INVESTIGATION IN THE USSR--PAST, PRESENT, AND FUTURE

Although the theoretical aspects of space investigation by means of rockets began in Russia at the end of the 19th century with the works of I. V. Meshcherskii on the dynamics of bodies of variable mass and those of K. E. Tsiolkovskii on the principles of rocket flight, the practical investigation of space did not begin until 1933, when Soviet scientists and engineers launched the first of a series of liquid-propellant atmospheric research rockets. In 1935, one of these rockets reached an altitude of 10 kilometers, which, Soviet historians carefully point out, bettered the 2.3-kilometer altitude attained by Professor Goddard's rocket in May of that year.

That the rocket showed promise as a scientific-research tool was immediately recognized by the Soviets: no less than seven papers on the use of rockets for atmospheric research were presented at the All-Union Conference on the Study of the Stratosphere, which met in Leningrad in March, 1934. The proceedings of the conference were published by the USSR Academy of Sciences in 1935.

This new rocket technique was so enthusiastically received by the scientific and technical community that an All-Union Conference on the Use of Rocket Devices for the Investigation of the Stratosphere was held in Moscow in March, 1935. The proceedings of this conference were published in three collections of papers, two entitled Reaktivnoe Dvizhenie (Jet Propulsion), published in 1935 and 1936, and one entitled Raketnaya Tekhnika (Rocket Technology), published in 1935. Most of the authors of these papers were members of Osoaviakhim (Society for the Promotion of Defense and the Aero-Chemical Industry) and Avianito (All-Union Aviation Scientific,

Engineering and Technical Society). The 28 papers comprising these three collections bear unmistakable evidence of native competence in the various aspects of rocketry and space flight and clearly indicate that the Russians possessed a relatively high degree of technical sophistication more than two decades ago.

Quick to realize the tremendous military potential of the rocket, the Soviets had organized, by 1934, a Government-sponsored rocket-research program--only five years after Germany had embarked on its rocket program, but eight years before similar systematic Army-sponsored research began in the United States. Further publication of original papers on rocketry was summarily suspended for security reasons.

After World War II, the Russians thoroughly and systematically exploited not only German rocket powerplants and guidance and control equipment, but also German technical personnel. Returnees have indicated that German talents were used to re-establish the state-of-the-art in rockety as it had existed in Germany in 1945 and to carry out fundamental research and design work under Soviet guidance, which led to the development of the Soviet Union's current large-thrust rockets.

By 1949, the Soviets had embarked on an upper-atmosphere research-rocket program that involved the recovery, by parachute, first of test-instrument containers and later of experimental animals. Papers dealing with this program were not presented, however, until December, 1956. A single-stage rocket launched initially in May, 1949, attained an altitude of 110 kilometers with an instrument payload of 120 kilograms. With improved techniques, larger payloads were sent to higher altitudes. Thus, in May, 1957, a single-stage geophysical rocket raised a 2200-kilogram pay-

load, including two dogs, to an altitude of 212 kilometers (the dogs experienced 360 to 370 seconds of weightlessness); and on February 21, 1958, an improved single-stage geophysical rocket raised an instrument payload of 1520 kilograms to a record altitude of 473 kilometers. In each case the payload was recovered by parachute.

The existence of an official Soviet space-technology program in 1953 may be traced to a significant statement by Academician A. N. Nesmeyanov, President of the USSR Academy of Sciences, who on November 27 of that year, said: "Science has reached a state when it is feasible to send a stratoplane to the moon, to create an artificial satellite of the earth."

The seriousness of Soviet interest in space technology became apparent on September 24, 1954, when the Presidium of the USSR Academy of Sciences established the K. E. Tsiolkovskii Gold Medal for outstanding work in the field of interplanetary communications, to be awarded every three years, beginning with 1957. To date, the medalist has not been named. More significant is the fact that the Presidium also established--sometime in 1954--a permanent Interdepartmental Commission on Interplanetary Communications to assist, in every way possible, the development of Soviet theoretical and practical work concerning the investigation of space and the achievement of manned space flight. The Commission joined the International Astronautical Federation in 1957, when, for the first time, a list of 27 members, including eight academicians and several high-ranking military officers, was made public.

The Soviets gave an indication of things to come with their announcement on August 27, 1957, of a successful test of an intercontinental ballistic missile capable of carrying a powerful nuclear weapon to any point of the globe. To prove to the world that their possession of the ICBM was fact,

not fantasy, the Soviets followed through with an unprecedented display of propulsive might by launching a series of three artificial satellites, on October 4 and November 3, 1957, and on May 15, 1958. These satellites, each more highly instrumented than its predecessor, had masses of 83.6, 508.3, and 1327 kilograms, respectively. Their initial perigee altitudes were 227, 225, and 226 kilometers, while their corresponding apogee altitudes were 947, 1671, and 1881 kilometers, respectively. Sputnik II carried the first true space passenger, Laika--the canine martyr to science. Sputnik III was large enough to accommodate a man.

Then, apparently following the time-table of a well-planned and well-organized space-investigation program, the Soviets launched an interplanetary rocket on January 2, 1959, at 2000 hours (Moscow time). The last stage of the rocket, after burn-out, reportedly has a mass of 1472 kilograms of which 361.3 kilograms represent instrumentation and batteries. This device, variously known as Lunik or Mechta, subsequently went into heliocentric orbit between the earth and Mars.

To track the flight of their earth satellites and interplanetary rockets, the Soviets have developed a complex network of measuring facilities located throughout the USSR. These include a radio guidance system for controlling the initial trajectory of the rockets, automatic radar-tracking installations, telemetering stations, low-frequency radio receiving stations, optical means for observing and tracking the space vehicles, and a data-processing center. Wide use has been made of the Soviet Union's radio amateurs, about 10,000 of whom have tracked the Sputniks on the 20- and 40-megacycle frequencies. Professional tracking stations have been established by some 28 DOSAAF (The All-Union Volunteer Society for the Promotion of the

Army, Aviation, and Navy) radio clubs. Tracking is also performed by every astronomical observatory in the Soviet Union, by several technical institutes, and by approximately 77 special optical observatories or Moonwatch stations. There is also a network of about 45 optical observatories in the Communist countries outside the Soviet Union.

Sputniks I and II were each equipped with two radio transmitters operating on frequencies of 20.005 and 40.002 megacycles. Instrumentation in these satellites was designed to obtain information on the physical properties of the atmosphere and the ionosphere, the earth's magnetic field, cosmic rays, solar x-ray and ultraviolet radiation, and micrometeors, as well as biological data on the behavior of the canine passenger in Sputnik II. Reports indicate that only a part of the desired information was successfully telemetered.

Sputnik III, which is still in orbit, has an instrumentation package of 968 kilograms, including chemical and solar batteries. It is a veritable space laboratory equipped with a variety of devices to study atmospheric pressure and density, the composition of the ionosphere, the concentration of charged particles, ionization intensity in the upper atmosphere, electrostatic fields, the earth's magnetic field, micrometeors, cosmic rays, and the sun's corpuscular radiation. Sputnik III reportedly carries several radio transmitters for tracking purposes, one of which, operating on 20.005 megacycles, is a high-power device designed primarily for the reception of its signals by amateur radio receivers. The satellite's high-resolution multichannel radio-telemetering system has a high-volume capacity and includes a number of devices for data storage. As the satellite flies over special tracking stations located within the borders of the USSR, these data are rapidly transmitted to earth on an unannounced frequency.

The interplanetary vehicle Mechta is carrying 361.3 kilograms of batteries and instrumentation. The latter is more sophisticated than that in Sputnik III and was designed for the study of the various aspects of cosmic radiation, terrestrial and solar corpuscular radiation, magnetic fields, meteoritic particles, and the gaseous components of interplanetary matter. Cosmic-ray data were transmitted by varying the modulation of the carrier frequency of a transmitter operating on 19.995 and 19.997 megacycles. Other scientific data were transmitted on 19.993 megacycles by varying the length of the intervals between signals. Control of the rocket's trajectory to a distance of 4000 to 5000 kilometers and the determination of its elements were carried out by means of a system operating on 183.6 megacycles.

Soviet facilities tracked Mechta's radio signals past the moon for a distance of some 597,000 kilometers. During this flight, USSR ground tracking stations allegedly maintained "reliable radio communication" with the rocket and received trajectory and measurement data from the vehicle's telemetering apparatus until its radio transmitters failed after 62 hours. On January 3, 1959, at 0357 hours (Moscow time), an artificial comet was formed by the ejection of sodium vapor from the vehicle and was used as an optical check of the rocket's deviation from its prescribed trajectory; the rocket was then at a distance of 113,000 kilometers from the earth.

There is no doubt that Soviet space exploration is advancing rapidly and according to a systematic plan. Portions of this plan were outlined by a Professor G. V. Petrovich in the March, 1959, issue of Vestnik Akademii Nauk SSSR (Herald of the USSR Academy of Sciences). According to this program rocket technology aimed at the study and mastery of the cosmos is being developed in three phases, all of which are proceeding simultaneously.

The first phase involves the creation of a series of artificial earth satellites varying in tonnage and purpose. The primary object is to establish in polar orbits a group of stabilized so-called observer-satellites equipped with optical and television instruments that will put the entire earth under constant surveillance. This phase of the program also includes the recovery of satellites or their essential parts, with and without the use of aerodynamic surfaces. Recovery techniques are being perfected that will at first permit instrument containers to be retrieved, then animals, and finally human passengers. As techniques improve and methods become more reliable, the satellites will become larger and their mean altitude above the earth will increase from a few hundred kilometers for the first surveillance satellites to tens of thousands of kilometers for intermediate space stations, the latter eventually being used to service interplanetary vehicles.

The second phase in the study and conquest of space is linked with the earth's natural satellite--the moon. The initial step in this phase of the program was accomplished when the Soviet interplanetary rocket Mechta passed by the moon at a distance of less than 6000 kilometers on its way into orbit around the sun. Subsequent steps will involve (a) circumflight of the moon with photography of its far side and transmission of the image to the earth as the rocket heads back toward the earth; (b) creation of artificial satellites of the moon which maintain constant communication with the earth; (c) deposition on the moon of heavy instrument packages containing radio, television, and telemetering equipment for the communication and transmission of scientific findings to the earth (for this step the rocket must have a characteristic velocity of 14.5 km/sec, that is, 11.2 km/sec to escape from the earth, 3 km/sec to land

on the moon, and a small increment for navigational corrections); (d) circumflight of the moon by a manned rocket with subsequent return to the earth; and (e) deposition on the moon of a manned rocket capable of taking off from the moon and returning to the earth (for this the vehicle must have a characteristic velocity of slightly more than 17 km/sec). This last step can also be achieved by means of less powerful rockets if stores and propellant supplies are deposited on the moon in advance to service and refuel the manned rocket for its return trip to the earth. As a precautionary measure, and at the same time to enhance the chances of a successful expedition, Soviet scientists consider it expedient to dispatch two "lunar" rockets simultaneously. The crews could be of mutual assistance to each other in exploring the moon and in preparing for the return trip; and, in case of emergency, they could return to earth in one rocket.

The third phase of the program concerns the investigation of the planets of our solar system by means of (a) automatic reconnaissance rockets that will probe both the inner and the outer planets and (b) a series of artificial satellites of the sun, of which Mechta is the prototype, that will move in prescribed orbits and continuously transmit information to earth. These probes and solar satellites are a necessary prerequisite for the further penetration of the cosmos.

Petrovich lists the following requirements as being necessary to achieve full development of the program. (a) the creation of larger and more effective rockets powered by engines with higher specific thrust; (b) improved systems of rocket stabilization and control, as well as improved ground launching facilities; (c) the perfection of high-resolution multichannel telemetering equipment to transmit signals to earth over distances measured

in millions of kilometers; and (d) the broad development of space medicine, since the time is rapidly approaching when this branch of science will be called on to make specific recommendations.

Enjoying the privileges of top priority in the field of space technology, Soviet scientists, engineers, and technicians are laboring feverishly to fulfill Tsiolkovskii's dictum: "Mankind will not stay on earth forever, but, in the pursuit of light and space, will at first timidly penetrate beyond the limits of the atmosphere and then will conquer all the space around the sun."

The Soviet regime is fanatically dedicated to the proposition that Soviet man will be first in space, first on the moon, and first in interplanetary communications. The implementation of this proposition probably began sometime in 1951 when, allegedly, Soviet scientists successfully recovered by means of a parachute their first canine stratospheric rocket passenger. Since that time the Soviets have made great strides along the road into the cosmos with the launching of their Sputniks and their interplanetary rocket Mechta. These accomplishments are tangible evidence of current Soviet capability for lunar rockets, planetary probes, and, possibly, lunar satellites.

Once Soviet scientists have solved the complex interdisciplinary problems associated with placing man in space and successfully recovering him--which they may very well do before the end of 1960--other technological advances in the conquest of space will follow as rapidly as the nation's economy will permit. The era of manned space exploration will begin soon thereafter; and Soviet astronauts will probably plant the insignia of the USSR on the moon by 1967, the 50th anniversary of Communist power and propaganda.